# Appendix

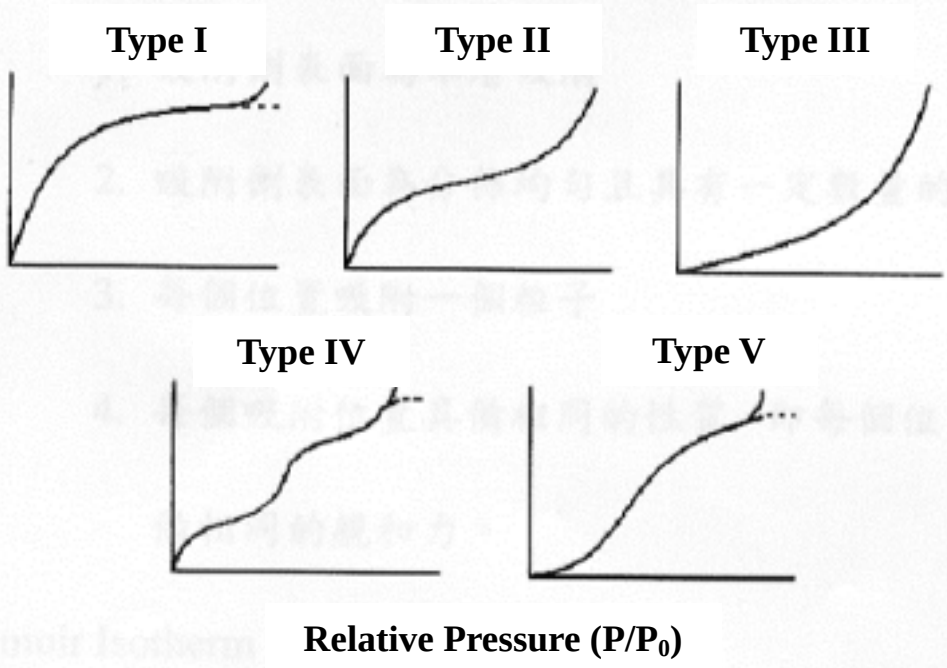



Fig. A-1. Types of Adsorption isotherms (蘇氏, 2004).

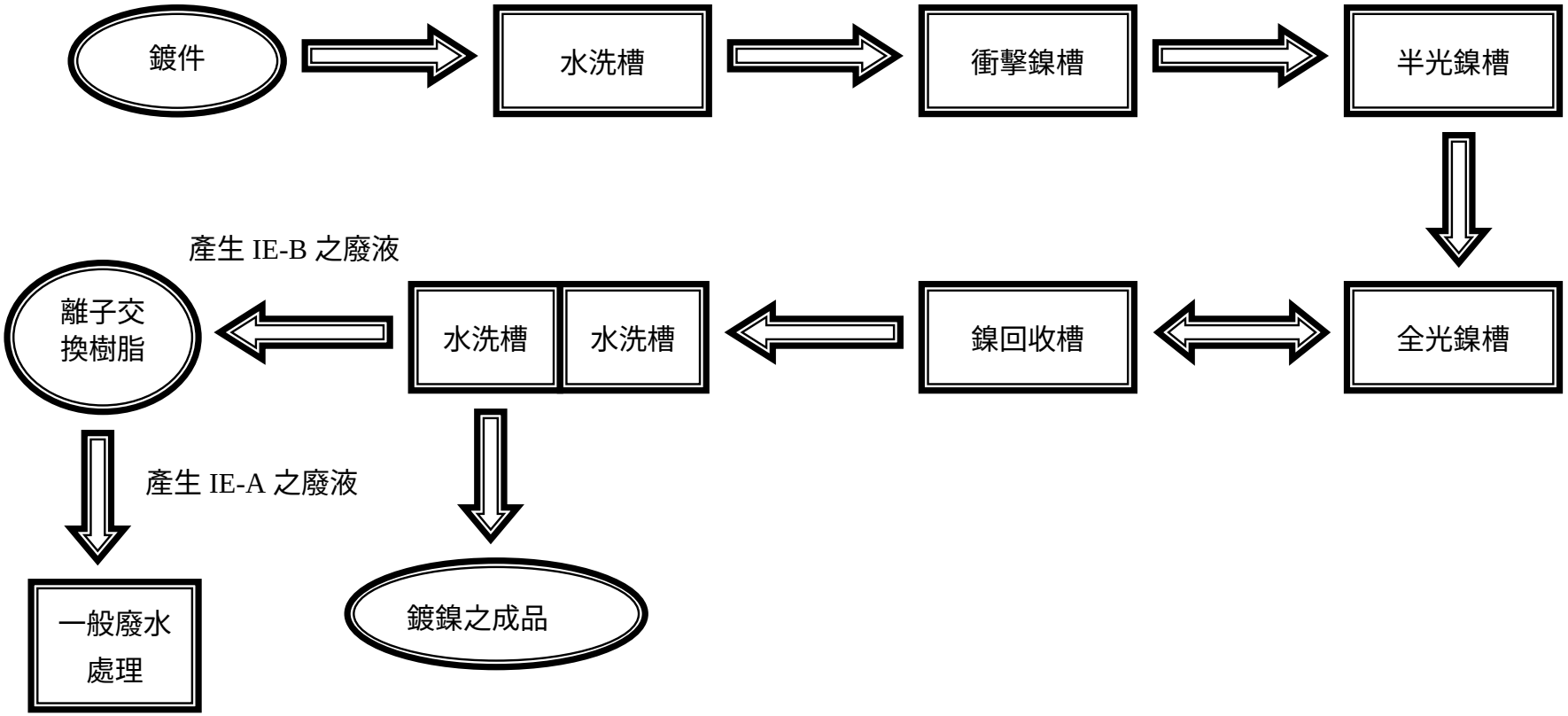
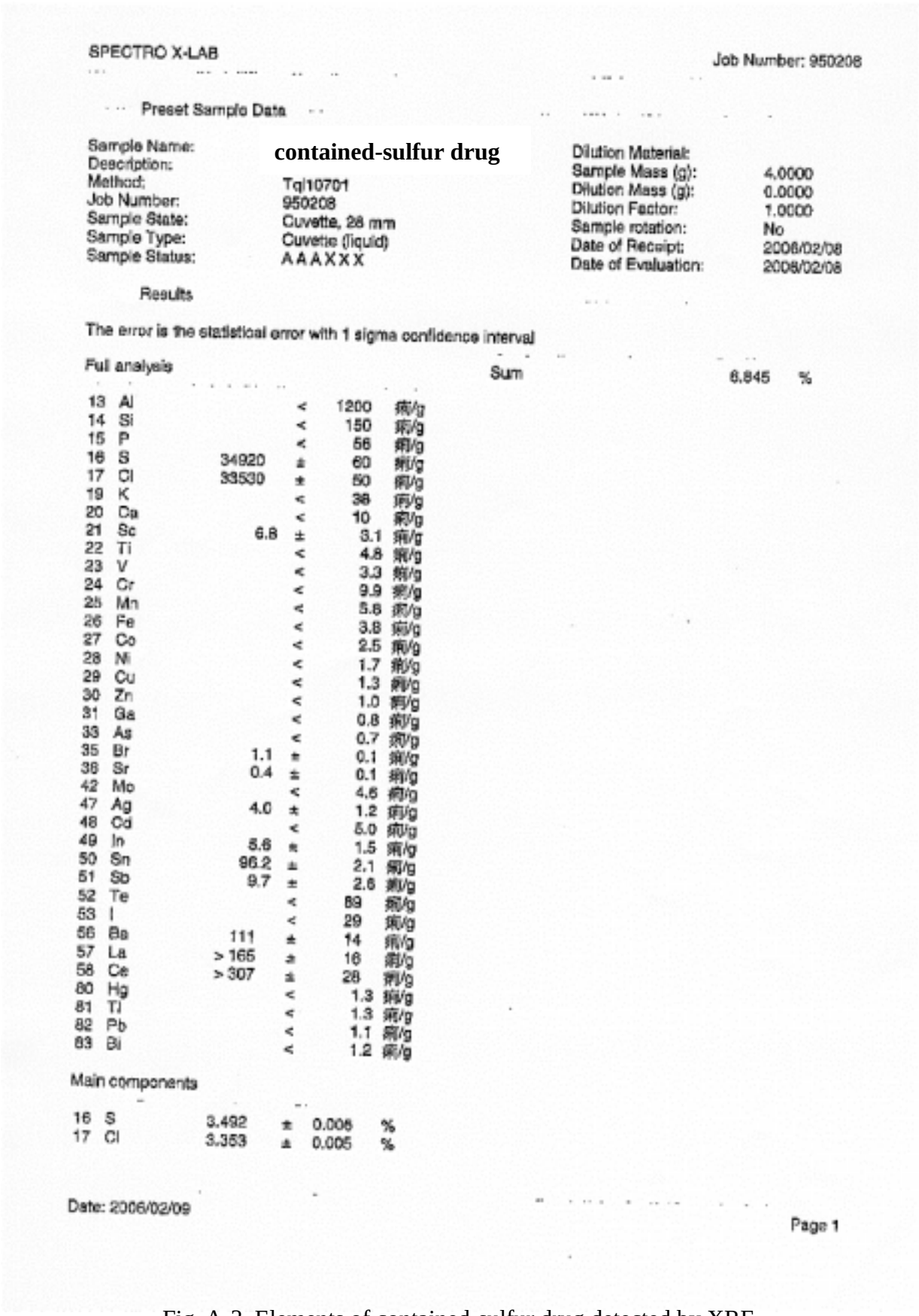



Fig. A-2. 電鍍製程及其廢水之產生流程



SPECTRO X-LAB

Job Number: 950208

Preset Sample Data

Sample Name: **contained-sulfur drug**
Description:
Method: Tql10701
Job Number: 950208
Sample State: Cuvette, 28 mm
Sample Type: Cuvette (liquid)
Sample Status: AAAXXX

Dilution Material:
Sample Mass (g): 4.0000
Dilution Mass (g): 0.0000
Dilution Factor: 1.0000
Sample rotation: No
Date of Receipt: 2006/02/08
Date of Evaluation: 2006/02/08

Results

The error is the statistical error with 1 sigma confidence interval

Full analysis

Sum 6.845 %

| | | | | | |
|---|---|---|---|---|---|
| 13 | Al | | < | 1200 | ppm/g |
| 14 | Si | | < | 150 | ppm/g |
| 15 | P | | < | 56 | ppm/g |
| 16 | S | 34920 | ± | 60 | ppm/g |
| 17 | Cl | 33530 | ± | 50 | ppm/g |
| 19 | K | | < | 38 | ppm/g |
| 20 | Ca | | < | 10 | ppm/g |
| 21 | Sc | 6.8 | ± | 3.1 | ppm/g |
| 22 | Ti | | < | 4.8 | ppm/g |
| 23 | V | | < | 3.3 | ppm/g |
| 24 | Cr | | < | 9.9 | ppm/g |
| 25 | Mn | | < | 5.6 | ppm/g |
| 26 | Fe | | < | 3.8 | ppm/g |
| 27 | Co | | < | 2.5 | ppm/g |
| 28 | Ni | | < | 1.7 | ppm/g |
| 29 | Cu | | < | 1.3 | ppm/g |
| 30 | Zn | | < | 1.0 | ppm/g |
| 31 | Ga | | < | 0.8 | ppm/g |
| 33 | As | | < | 0.7 | ppm/g |
| 35 | Br | 1.1 | ± | 0.1 | ppm/g |
| 38 | Sr | 0.4 | ± | 0.1 | ppm/g |
| 42 | Mo | | < | 4.6 | ppm/g |
| 47 | Ag | 4.0 | ± | 1.2 | ppm/g |
| 48 | Cd | | < | 5.0 | ppm/g |
| 49 | In | 5.6 | ± | 1.5 | ppm/g |
| 50 | Sn | 96.2 | ± | 2.1 | ppm/g |
| 51 | Sb | 9.7 | ± | 2.6 | ppm/g |
| 52 | Te | | < | 89 | ppm/g |
| 53 | I | | < | 29 | ppm/g |
| 56 | Ba | 111 | ± | 14 | ppm/g |
| 57 | La | > 165 | ± | 16 | ppm/g |
| 58 | Ce | > 307 | ± | 28 | ppm/g |
| 80 | Hg | | < | 1.3 | ppm/g |
| 81 | Tl | | < | 1.3 | ppm/g |
| 82 | Pb | | < | 1.1 | ppm/g |
| 83 | Bi | | < | 1.2 | ppm/g |

Main components

| | | | | | |
|---|---|---|---|---|---|
| 16 | S | 3.492 | ± | 0.006 | % |
| 17 | Cl | 3.353 | ± | 0.005 | % |

Date: 2006/02/09

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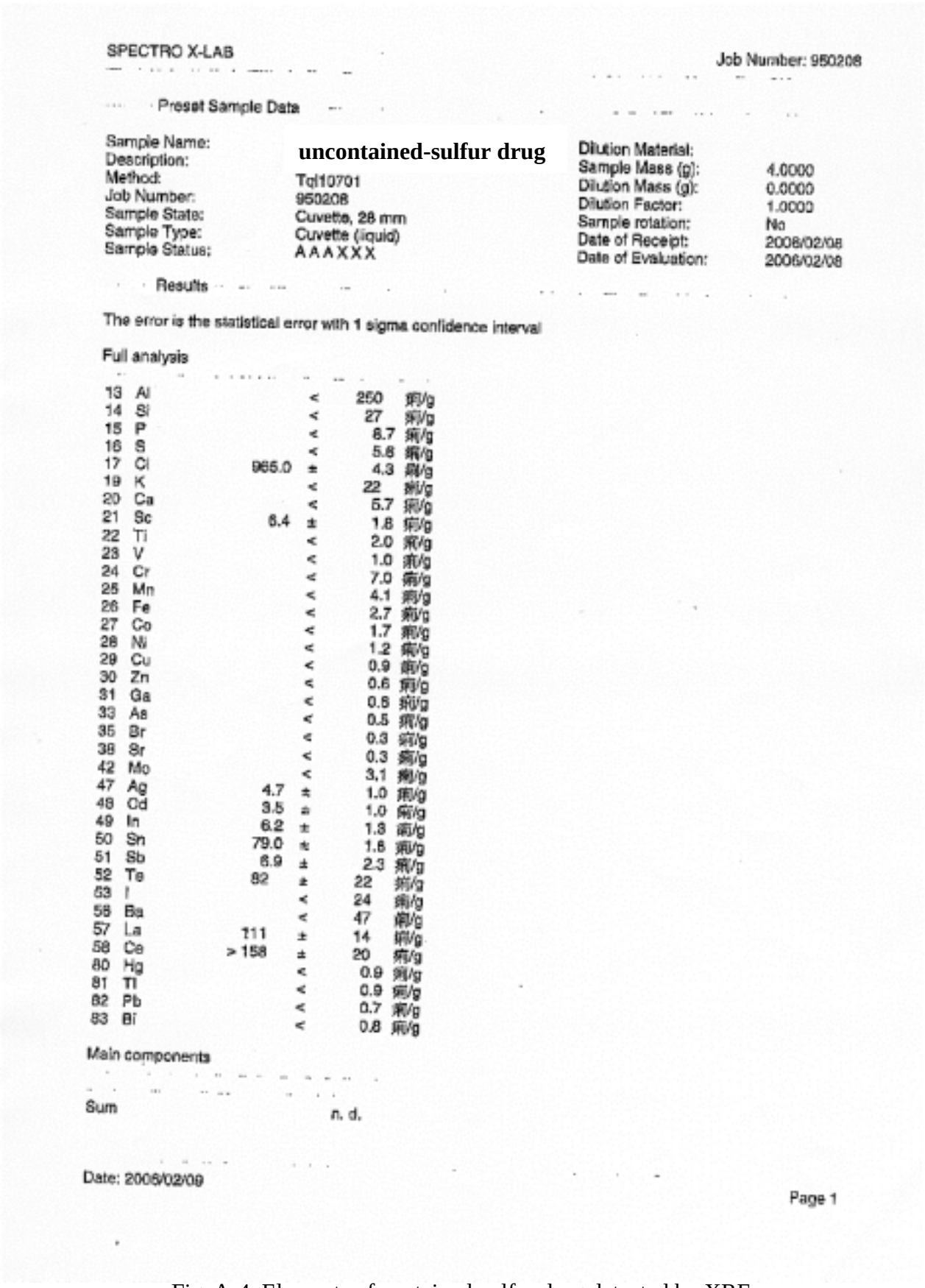
Fig. A-3. Elements of contained-sulfur drug detected by XRF.



SPECTRO X-LAB

Job Number: 950208

Preset Sample Data

| | | | |
|---|---|---|---|
| Sample Name: | **uncontained-sulfur drug** | Dilution Material: | |
| Description: | | Sample Mass (g): | 4.0000 |
| Method: | Tql10701 | Dilution Mass (g): | 0.0000 |
| Job Number: | 950208 | Dilution Factor: | 1.0000 |
| Sample State: | Cuvette, 28 mm | Sample rotation: | No |
| Sample Type: | Cuvette (liquid) | Date of Receipt: | 2006/02/08 |
| Sample Status: | AAAXXX | Date of Evaluation: | 2006/02/08 |

Results

The error is the statistical error with 1 sigma confidence interval

Full analysis

| | | | | | |
|---|---|---|---|---|---|
| 13 | Al | | < | 250 | 痢/g |
| 14 | Si | | < | 27 | 痢/g |
| 15 | P | | < | 6.7 | 痢/g |
| 16 | S | | < | 5.8 | 痢/g |
| 17 | Cl | 965.0 | ± | 4.3 | 痢/g |
| 19 | K | | < | 22 | 痢/g |
| 20 | Ca | | < | 5.7 | 痢/g |
| 21 | Sc | 6.4 | ± | 1.8 | 痢/g |
| 22 | Ti | | < | 2.0 | 痢/g |
| 23 | V | | < | 1.0 | 痢/g |
| 24 | Cr | | < | 7.0 | 痢/g |
| 25 | Mn | | < | 4.1 | 痢/g |
| 26 | Fe | | < | 2.7 | 痢/g |
| 27 | Co | | < | 1.7 | 痢/g |
| 28 | Ni | | < | 1.2 | 痢/g |
| 29 | Cu | | < | 0.9 | 痢/g |
| 30 | Zn | | < | 0.6 | 痢/g |
| 31 | Ga | | < | 0.5 | 痢/g |
| 33 | As | | < | 0.5 | 痢/g |
| 35 | Br | | < | 0.3 | 痢/g |
| 38 | Sr | | < | 0.3 | 痢/g |
| 42 | Mo | | < | 3.1 | 痢/g |
| 47 | Ag | 4.7 | ± | 1.0 | 痢/g |
| 48 | Cd | 3.5 | ± | 1.0 | 痢/g |
| 49 | In | 6.2 | ± | 1.3 | 痢/g |
| 50 | Sn | 79.0 | ± | 1.6 | 痢/g |
| 51 | Sb | 6.9 | ± | 2.3 | 痢/g |
| 52 | Te | 92 | ± | 22 | 痢/g |
| 53 | I | | < | 24 | 痢/g |
| 56 | Ba | | < | 47 | 痢/g |
| 57 | La | 111 | ± | 14 | 痢/g |
| 58 | Ce | > 158 | ± | 20 | 痢/g |
| 80 | Hg | | < | 0.9 | 痢/g |
| 81 | Tl | | < | 0.9 | 痢/g |
| 82 | Pb | | < | 0.7 | 痢/g |
| 83 | Bi | | < | 0.8 | 痢/g |

Main components

Sum n. d.

Date: 2006/02/09

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Fig. A-4. Elements of contained-sulfur drug detected by XRF.

SPECTRO X-LAB

Job Number: 940525

Preset Sample Data

| | | | |
|---|---|---|---|
| Sample Name: | **raw RH** | Dilution Material: | HWC |
| Description: | | Sample Mass (g): | 4.0000 |
| Method: | Tq10701 | Dilution Mass (g): | 0.9000 |
| Job Number: | 940525 | Dilution Factor: | 0.8163 |
| Sample State: | Pressed tablet, 32 mm | Sample rotation: | No |
| Sample Type: | Pressed tablet | Date of Receipt: | 2005/05/25 |
| Sample Status: | A A A X X X | Date of Evaluation: | 2005/05/25 |

Results

The error is the statistical error with 1 sigma confidence interval

Full Analysis

| | | | | | |
|---|---|---|---|---|---|
| 12 | Mg | | < | 0.50 | % |
| 13 | Al | | < | 0.10 | % |
| 14 | Si | 11.14 | ± | 0.01 | % |
| 15 | P | 0.09239 | ± | 0.00049 | % |
| 16 | S | 1198 | ± | 4 | ppm |
| 17 | Cl | 1580 | ± | 3 | ppm |
| 19 | K | 1.096 | ± | 0.004 | % |
| 20 | Ca | 0.2248 | ± | 0.0018 | % |
| 22 | Ti | | < | 0.0020 | % |
| 23 | V | | < | 15 | ppm |
| 24 | Cr | 55.4 | ± | 3.7 | ppm |
| 25 | Mn | 0.02352 | ± | 0.00040 | % |
| 26 | Fe | 0.05248 | ± | 0.00041 | % |
| 27 | Co | | < | 2.6 | ppm |
| 28 | Ni | 15.8 | ± | 0.8 | ppm |
| 29 | Cu | 7.9 | ± | 0.6 | ppm |
| 30 | Zn | 43.7 | ± | 0.6 | ppm |
| 31 | Ga | | < | 0.7 | ppm |
| 32 | Ge | | < | 0.7 | ppm |
| 33 | As | | < | 0.6 | ppm |
| 34 | Se | | < | 0.3 | ppm |
| 35 | Br | 1.8 | ± | 0.1 | ppm |
| 37 | Rb | 5.0 | ± | 0.1 | ppm |
| 38 | Sr | 0.00054 | ± | 0.00001 | % |
| 39 | Y | 2.7 | ± | 0.2 | ppm |
| 40 | Zr | | < | 50 | ppm |
| 47 | Ag | | < | 30 | ppm |
| 48 | Cd | | < | 30 | ppm |
| 50 | Sn | 68.3 | ± | 1.4 | ppm |
| 51 | Sb | | < | 6.0 | ppm |
| 52 | Te | | < | 59 | ppm |
| 53 | I | 14.5 | ± | 4.4 | ppm |
| 56 | Ba | 146 | ± | 11 | ppm |
| 80 | Hg | | < | 1.3 | ppm |
| 81 | Tl | | < | 1.1 | ppm |
| 82 | Pb | 4.6 | ± | 0.4 | ppm |
| 83 | Bi | | < | 1.2 | ppm |
| 90 | Th | | < | 1.2 | ppm |
| 92 | U | | < | 1.6 | ppm |

Main Compounds

| | | | | | |
|---|---|---|---|---|---|
| 14 | Si | 11.14 | ± | 0.01 | % |
| 16 | S | 0.1198 | ± | 0.0004 | % |
| 17 | Cl | 0.1580 | ± | 0.0003 | % |
| 19 | K | 1.096 | ± | 0.004 | % |
| 20 | Ca | 0.2248 | ± | 0.0018 | % |
| Sum | | | | 12.74 | % |

Date: 2005/05/26

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Fig. A-5. Elements of raw RH detected by XRF.

SPECTRO X-LAB

Job Number: 940525

Preset Sample Data

| | | | |
|---|---|---|---|
| Sample Name: | **raw RHA** | Dilution Material: | |
| Description: | | Sample Mass (g): | 4.0000 |
| Method: | Tqk10701 | Dilution Mass (g): | 0.0000 |
| Job Number: | 940525 | Dilution Factor: | 1.0000 |
| Sample State: | Cuvette, 28 mm | Sample rotation: | No |
| Sample Type: | Cuvette (powder) | Date of Receipt: | 2005/05/25 |
| Sample Status: | AAAXXX | Date of Evaluation: | 2005/05/25 |

Results

The error is the statistical error with 1 sigma confidence interval

Full Analysis

| | | | | | |
|---|---|---|---|---|---|
| 13 | Al | | < | 0.10 | % |
| 14 | Si | > 93.85 | ± | 0.22 | % |
| 15 | P | 1.092 | ± | 0.012 | % |
| 16 | S | 1704 | ± | 22 | ppm/g |
| 17 | Cl | 4052 | ± | 24 | ppm/g |
| 19 | K | 5.715 | ± | 0.022 | % |
| 20 | Ca | 1.387 | ± | 0.009 | % |
| 22 | Ti | 0.00494 | ± | 0.00022 | % |
| 23 | V | | < | 1.7 | ppm/g |
| 24 | Cr | 220 | ± | 10 | ppm/g |
| 25 | Mn | 0.1453 | ± | 0.0016 | % |
| 26 | Fe | 0.1274 | ± | 0.0013 | % |
| 27 | Co | | < | 7.9 | ppm/g |
| 28 | Ni | 42.0 | ± | 2.2 | ppm/g |
| 29 | Cu | 13.4 | ± | 1.6 | ppm/g |
| 30 | Zn | 172.8 | ± | 2.2 | ppm/g |
| 31 | Ga | | < | 2.1 | ppm/g |
| 32 | Ge | | < | 2.1 | ppm/g |
| 33 | As | 3.5 | ± | 0.7 | ppm/g |
| 34 | Se | | < | 0.9 | ppm/g |
| 35 | Br | 2.7 | ± | 0.3 | ppm/g |
| 37 | Rb | 23.9 | ± | 0.4 | ppm/g |
| 38 | Sr | 0.00246 | ± | 0.00004 | % |
| 39 | Y | 12.3 | ± | 0.4 | ppm/g |
| 40 | Zr | | < | 50 | ppm/g |
| 47 | Ag | 3.3 | ± | 0.7 | ppm/g |
| 48 | Cd | | < | 4.4 | ppm/g |
| 50 | Sn | 35.6 | ± | 1.0 | ppm/g |
| 51 | Sb | | < | 6.7 | ppm/g |
| 52 | Te | | < | 58 | ppm/g |
| 53 | I | | < | 12 | ppm/g |
| 56 | Ba | 95.3 | ± | 7.0 | ppm/g |
| 80 | Hg | | < | 3.9 | ppm/g |
| 81 | Tl | | < | 3.0 | ppm/g |
| 82 | Pb | 18.5 | ± | 1.0 | ppm/g |
| 83 | Bi | | < | 3.4 | ppm/g |
| 90 | Th | | < | 3.4 | ppm/g |
| 92 | U | | < | 5.1 | ppm/g |

Main Compounds

| | | | | | |
|---|---|---|---|---|---|
| 15 | P | 1.092 | ± | 0.012 | % |
| 16 | S | 0.1704 | ± | 0.0022 | % |
| 17 | Cl | 0.4052 | ± | 0.0024 | % |
| 19 | K | 5.715 | ± | 0.022 | % |
| 20 | Ca | 1.387 | ± | 0.009 | % |
| 25 | Mn | 0.1453 | ± | 0.0016 | % |
| 26 | Fe | 0.1274 | ± | 0.0013 | % |
| Sum | | | | 102.9 | % |

Main Compounds

| | | | | | |
|---|---|---|---|---|---|
| 14 | Si | > 93.85 | ± | 0.22 | % |

Date: 2005/05/26

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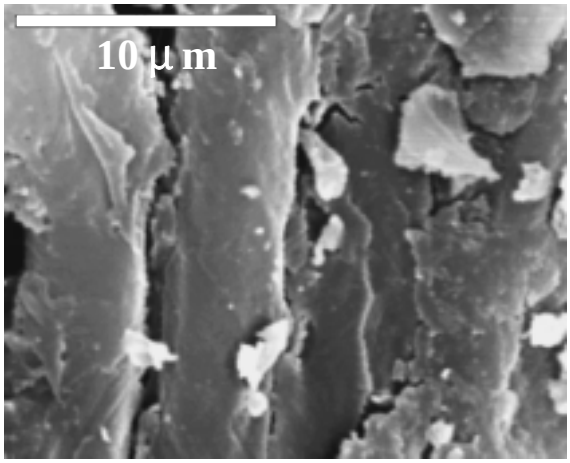
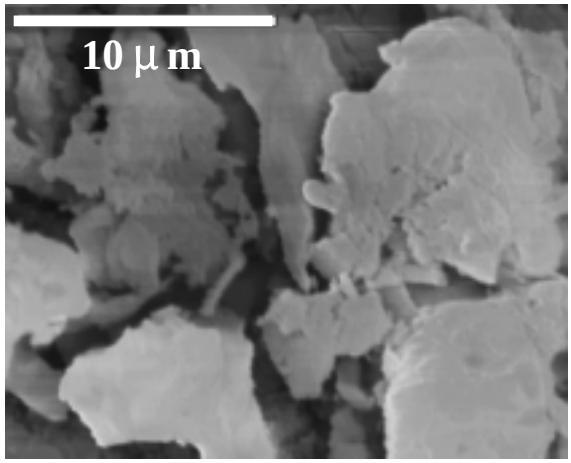
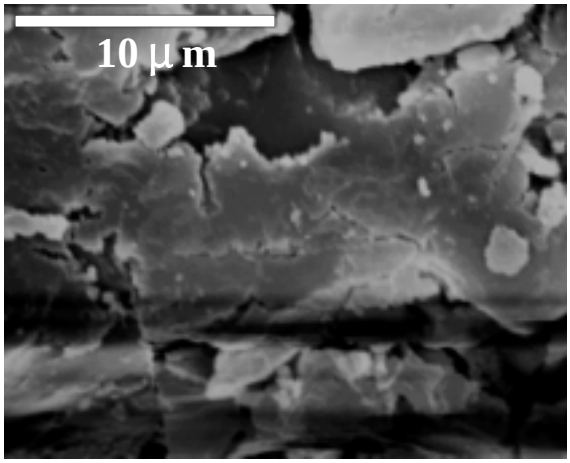
Fig. A-6. Elements of raw RHA detected by XRF.



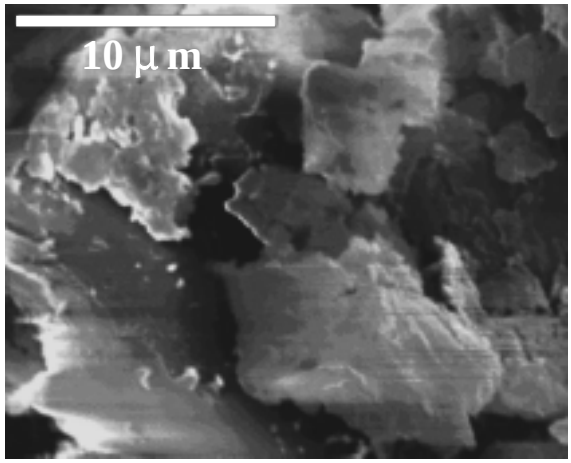

raw RH




RH-Ni ($NiSO_4$)-0.5 h

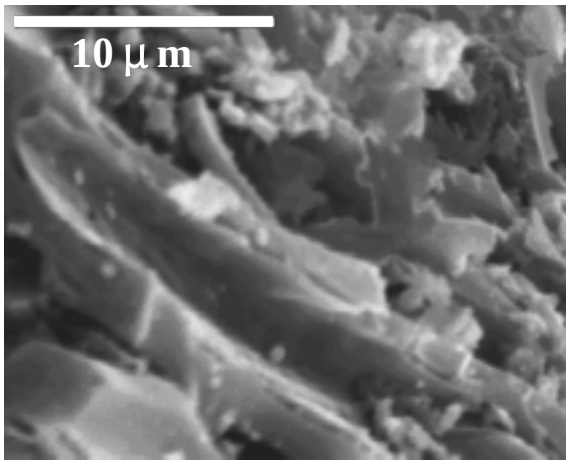



RH-Ni ($NiSO_4$)-12 h

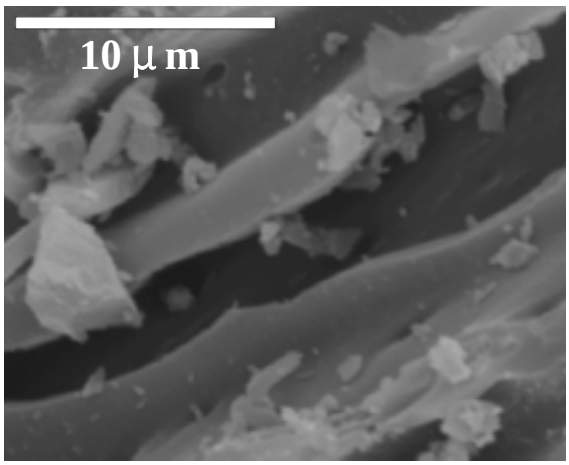



RH-Ni ($NiSO_4$)-24 h

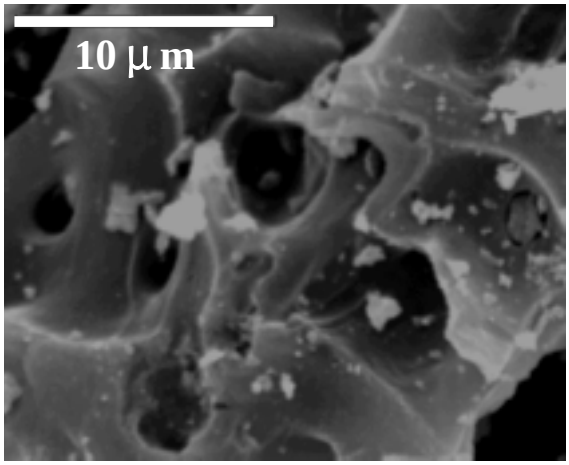
Fig. A-7. Morphology (x 5000) of raw RH and the RH samples that sorb nickel from 2000 mg/L Ni (II) solution for 0.5, 12 and 24 h.



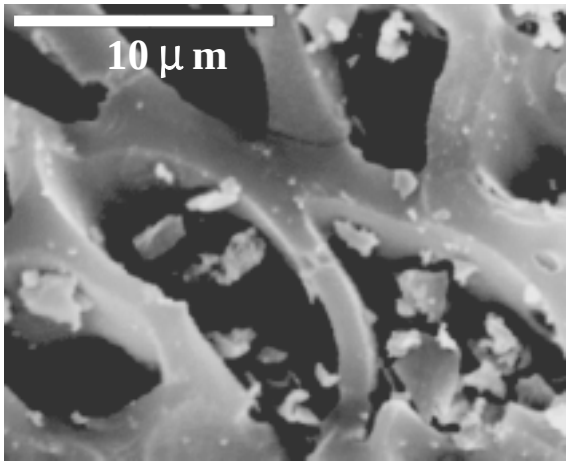

raw RHA




RHA-Ni ($NiSO_4$)-0.5 h




RHA-Ni ($NiSO_4$)-12 h




RHA-Ni ($NiSO_4$)-24 h

Fig. A-8. Morphology (x 5000) of raw RHA and and the RHA samples that sorb nickel from 2000 mg/L Ni (II) solution for 0.5, 12 and 24h.

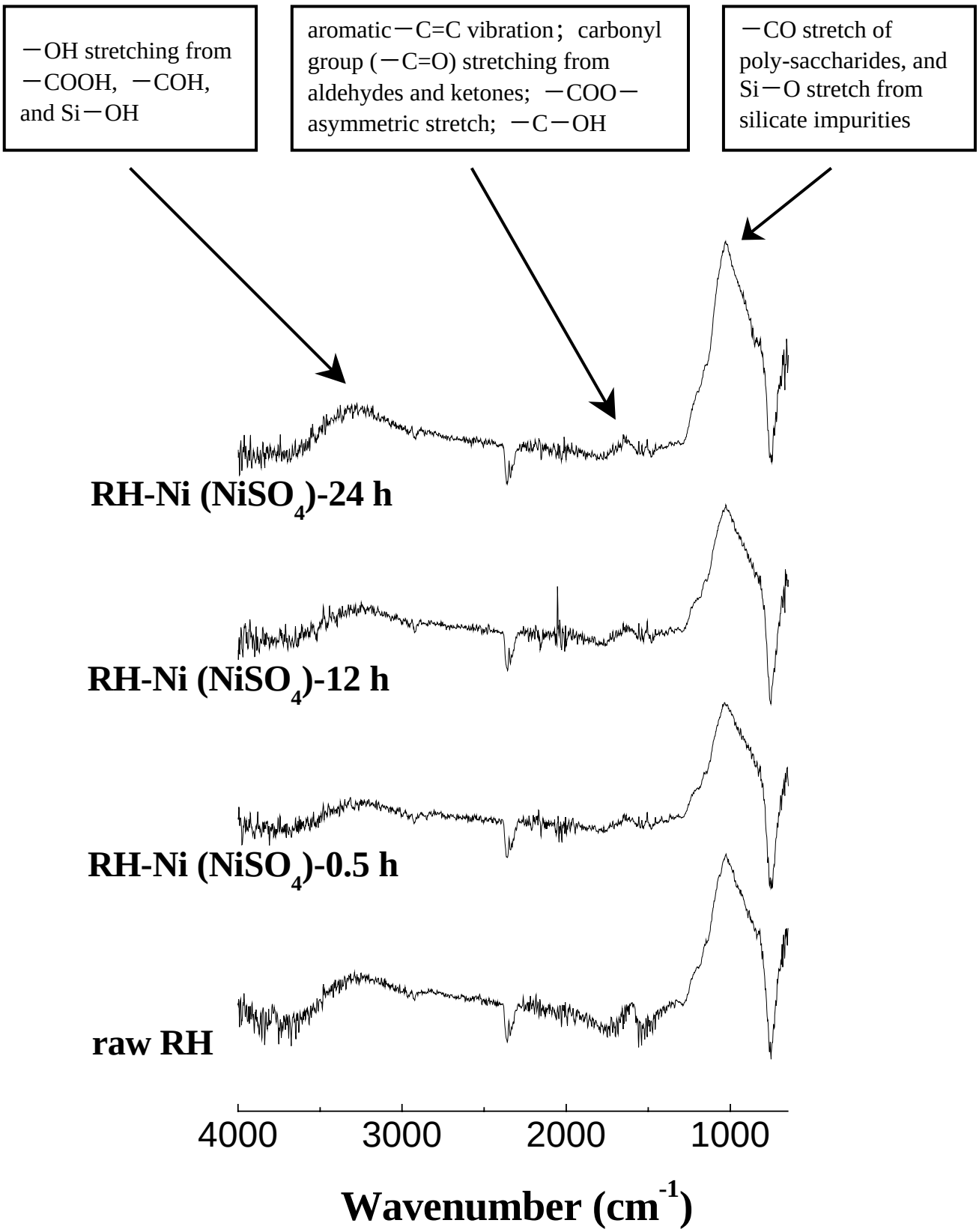



Fig. A-9. FT-IR spectra of raw RH and the RH samples that sorb nickel from 2000 mg/L Ni (II) solution for 0.5, 12 and 24h.

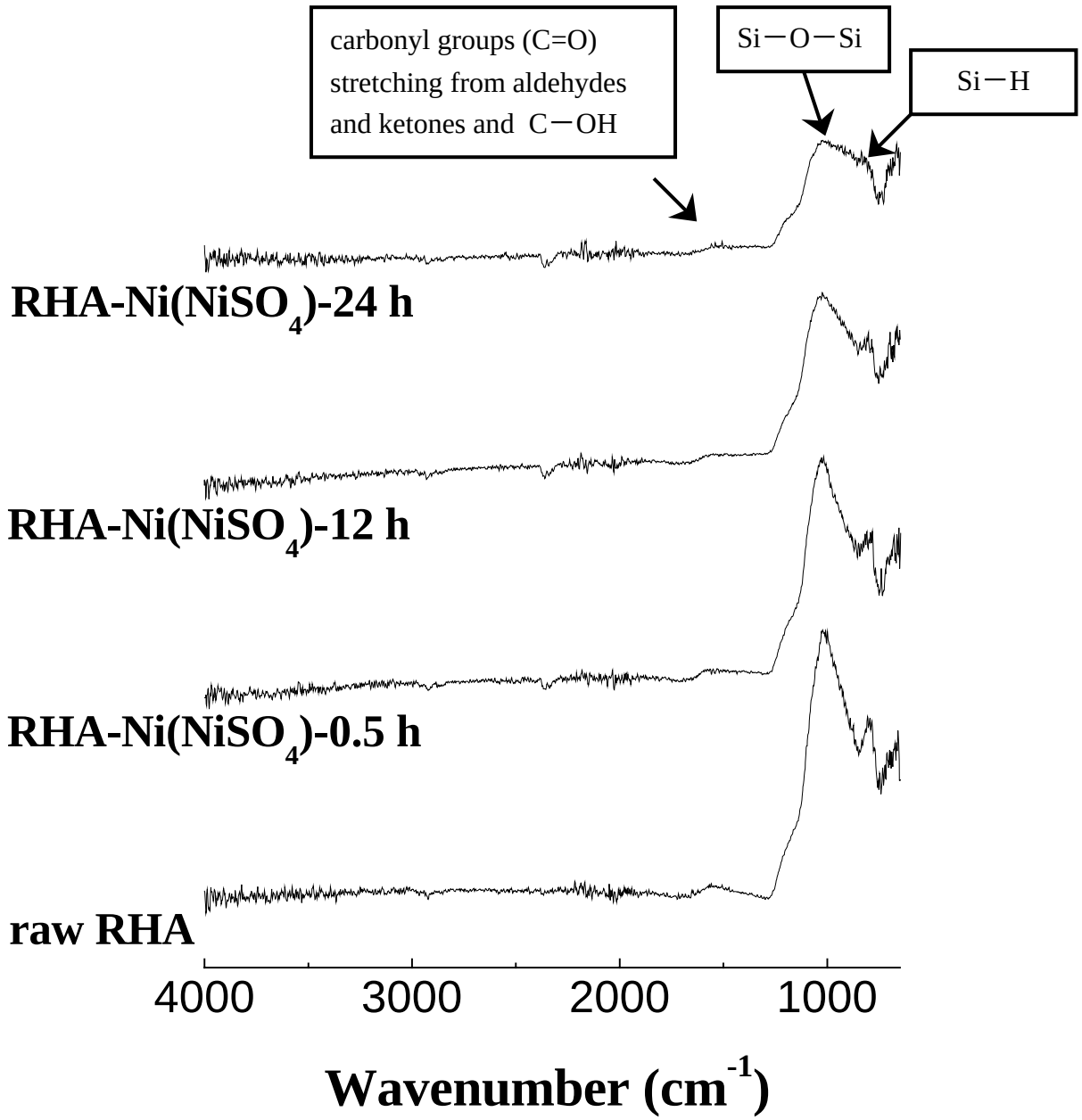
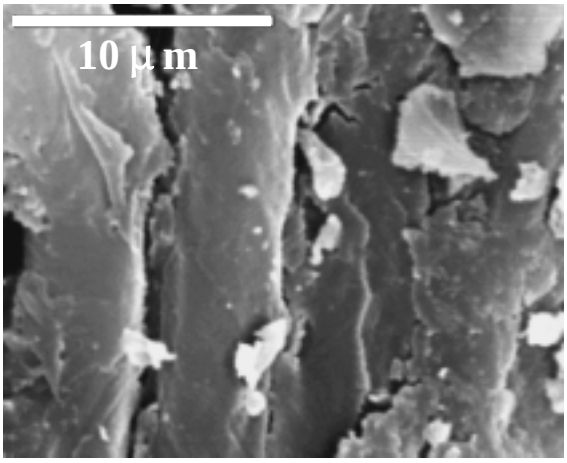
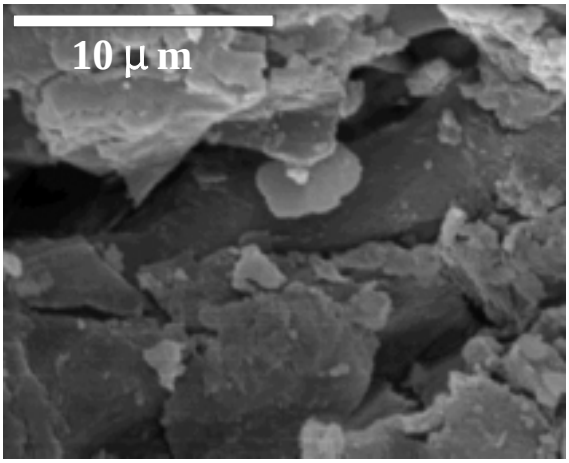


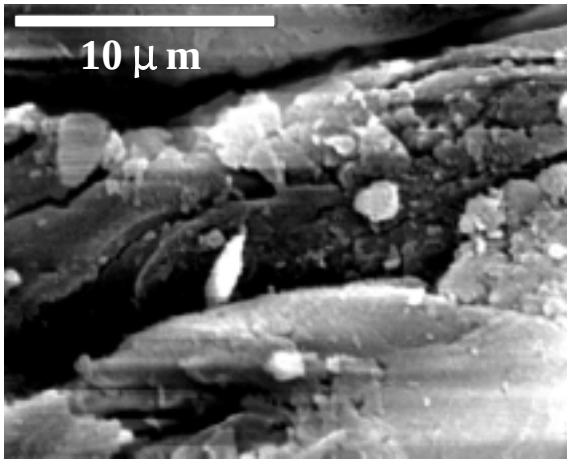

Fig. A-10. FT-IR spectra of raw RHA and and the RHA samples that sorb nickel from 2000 mg/L Ni (II) solution for 0.5, 12 and 24h.



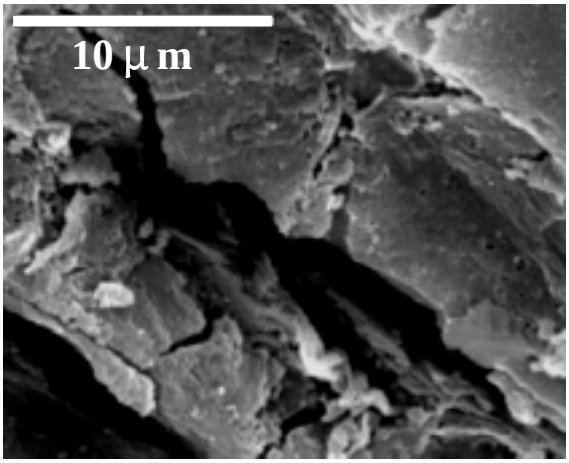

raw RH




RH-Ni (plating)-0.5 h

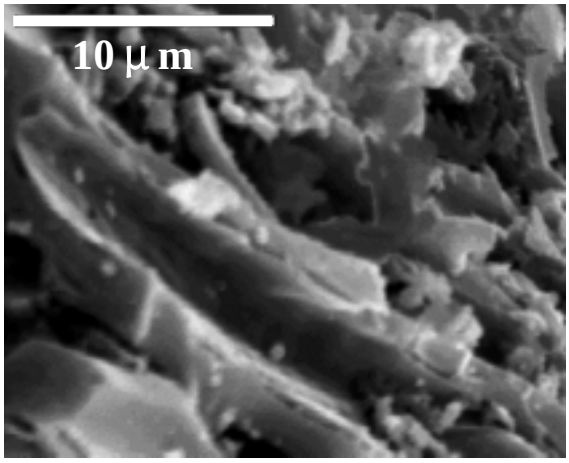



RH-Ni (plating)-12 h

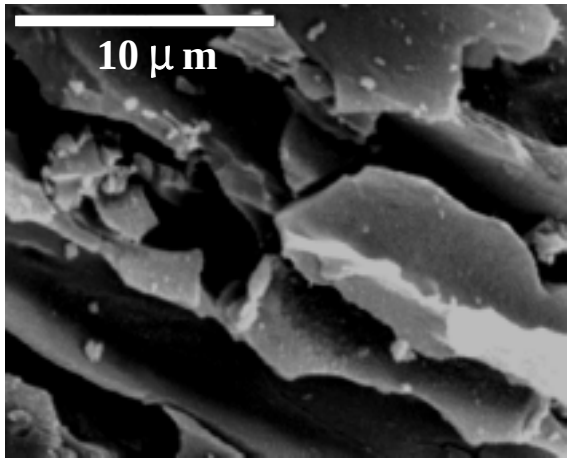



RH-Ni (plating)-24 h

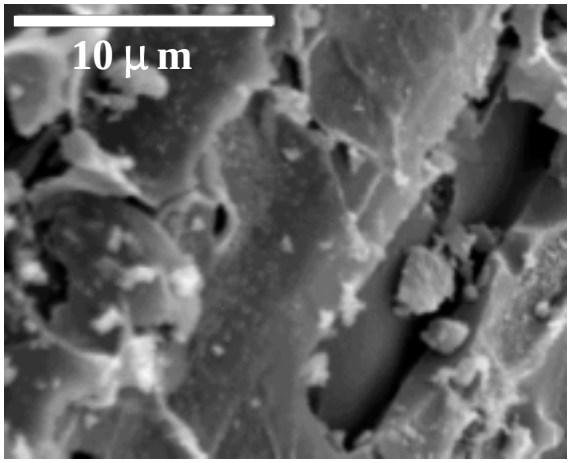
Fig. A-11. Morphology (x5000) of raw RH and the RH samples that sorb nickel from plating wastewater for 0.5, 12, 24 h.



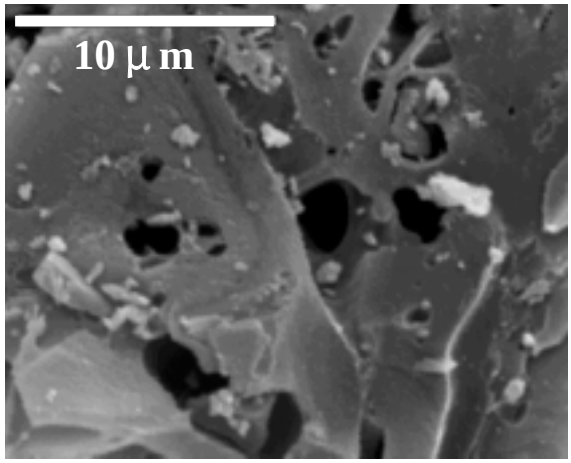

raw RHA




RHA-Ni (plating)-0.5 h




RHA- Ni (plating)-12 h




RHA- Ni (plating)-24 h

Fig. A-12. Morphology (x5000) of raw RHA and the RHA samples that sorb nickel from plating wastewater for 0.5, 12, 24 h.

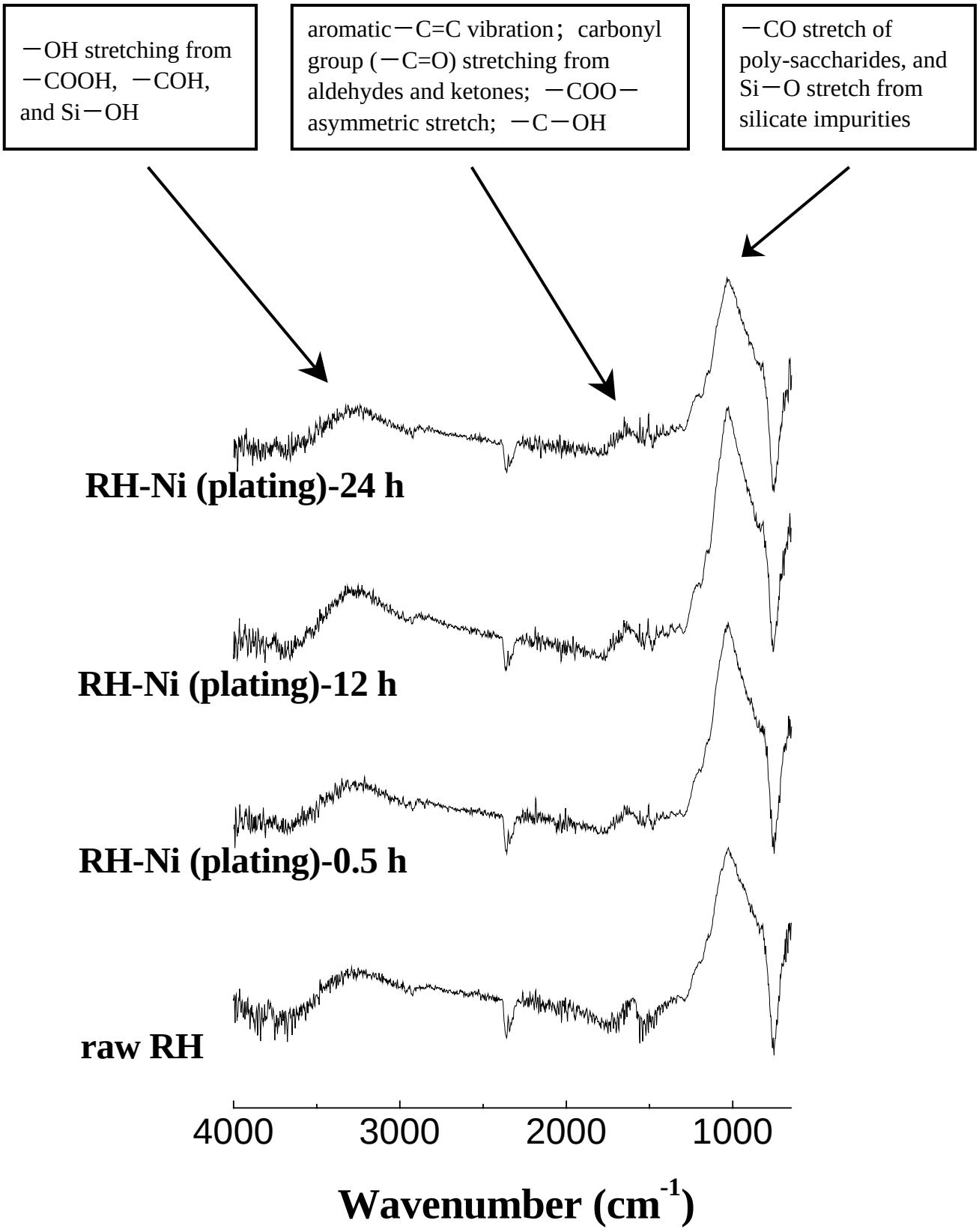



Fig. A-13. FT-IR spectra of raw RH and the RH samples that sorb nickel from plating wastewater for 0.5, 12 and 24h.

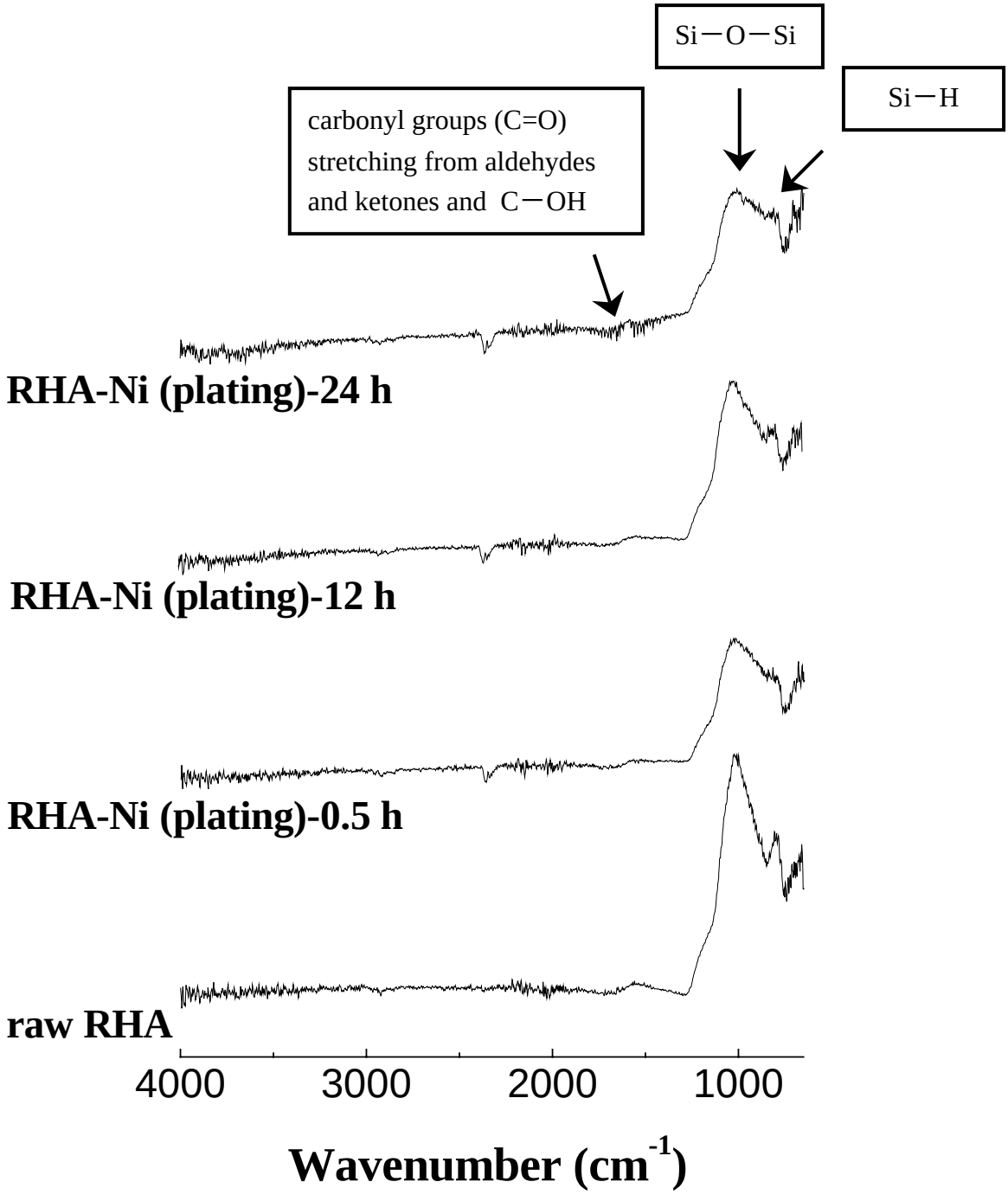
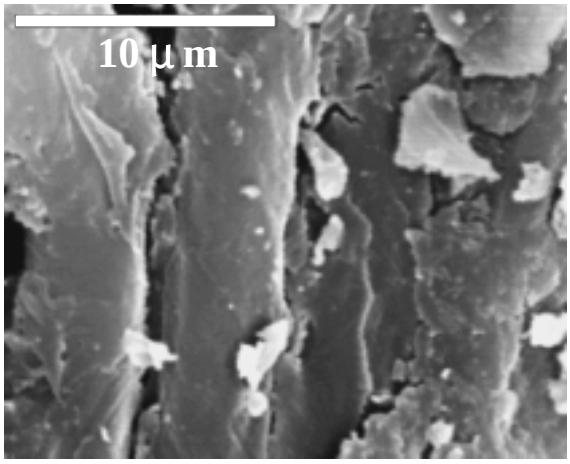
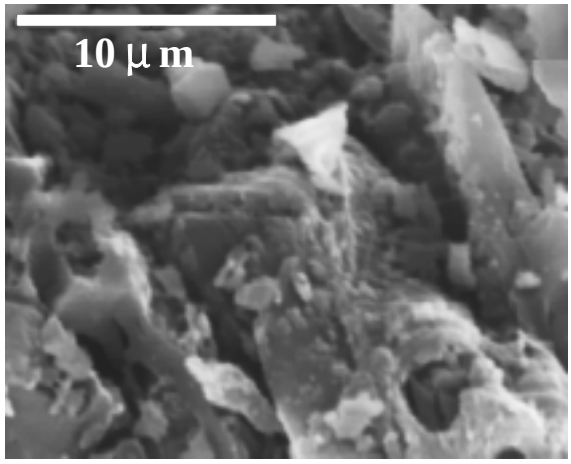


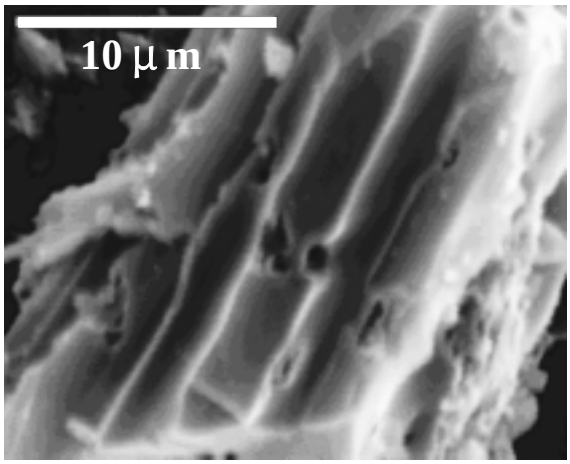

Fig. A-14. FT-IR spectra of raw RHA and the RHA samples that sorb nickel from plating wastewater for 0.5, 12 and 24h.



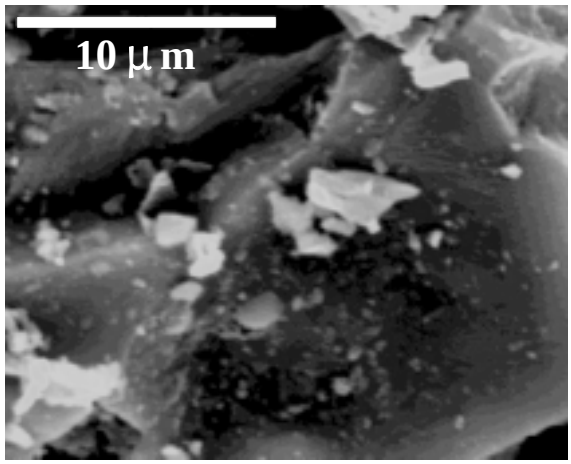

raw RH-105 $^{o}$C




raw RH-500 $^{o}$C

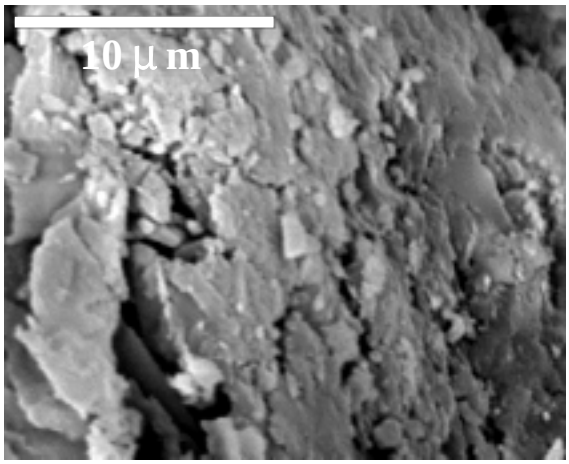



raw RH-900 $^{o}$C

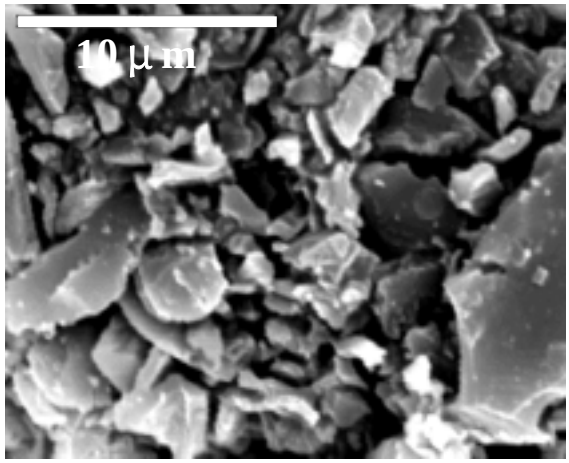



raw RH-1100 $^{o}$C

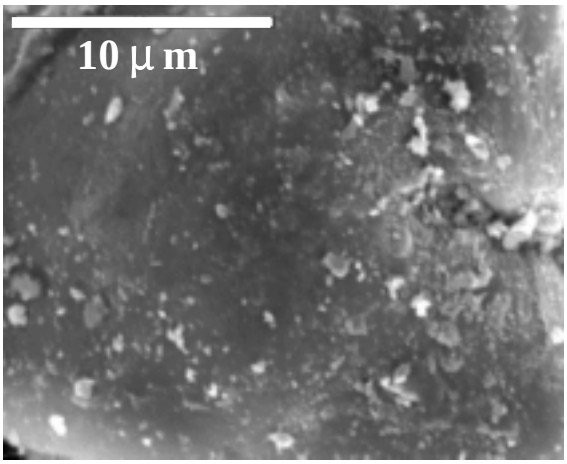
Fig. A-15. Morphology (x5000) of raw RH samples after heating at different temperatures.



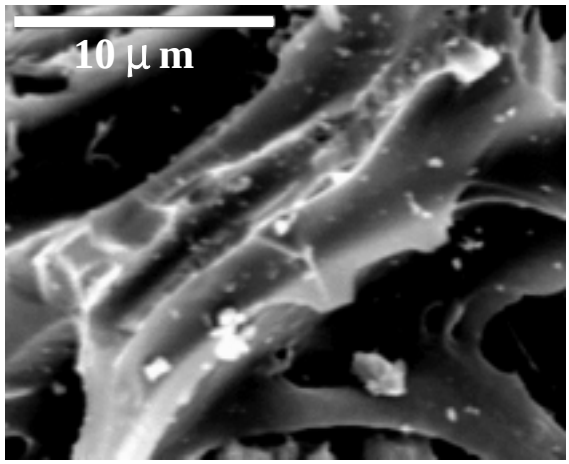

RH-Ni ($NiSO_4$)-105 $^oC$




RH-Ni ($NiSO_4$)-500 $^oC$




RH-Ni ($NiSO_4$)-900 $^oC$




RH-Ni ($NiSO_4$)-1100 $^oC$

Fig. A-16. Morphology (x5000) of Ni ($NiSO_4$)-containing RH samples after heating at different temperatures.

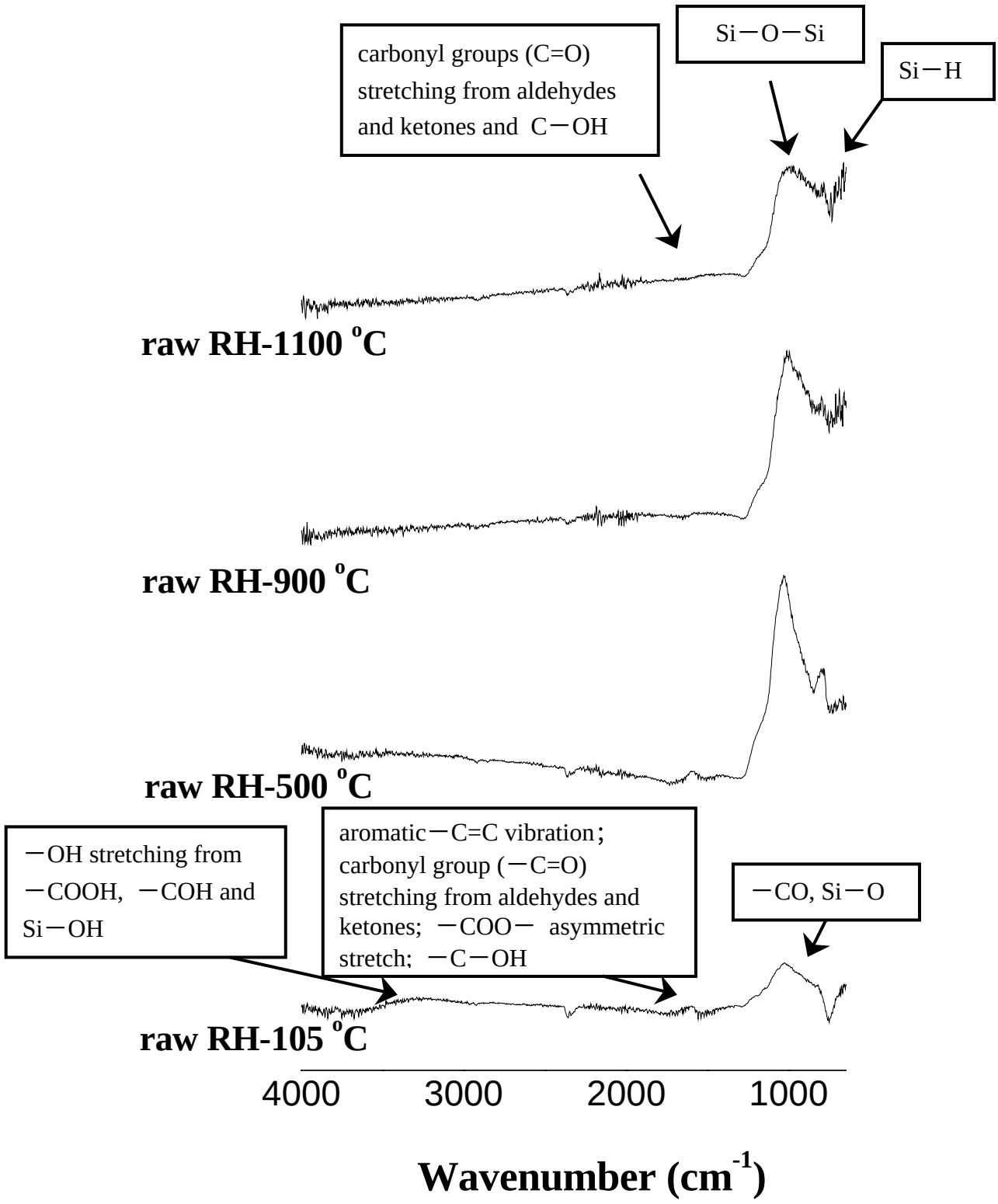



Fig. A-17. FT-IR spectra of raw RH samples after heating at different temperatures.

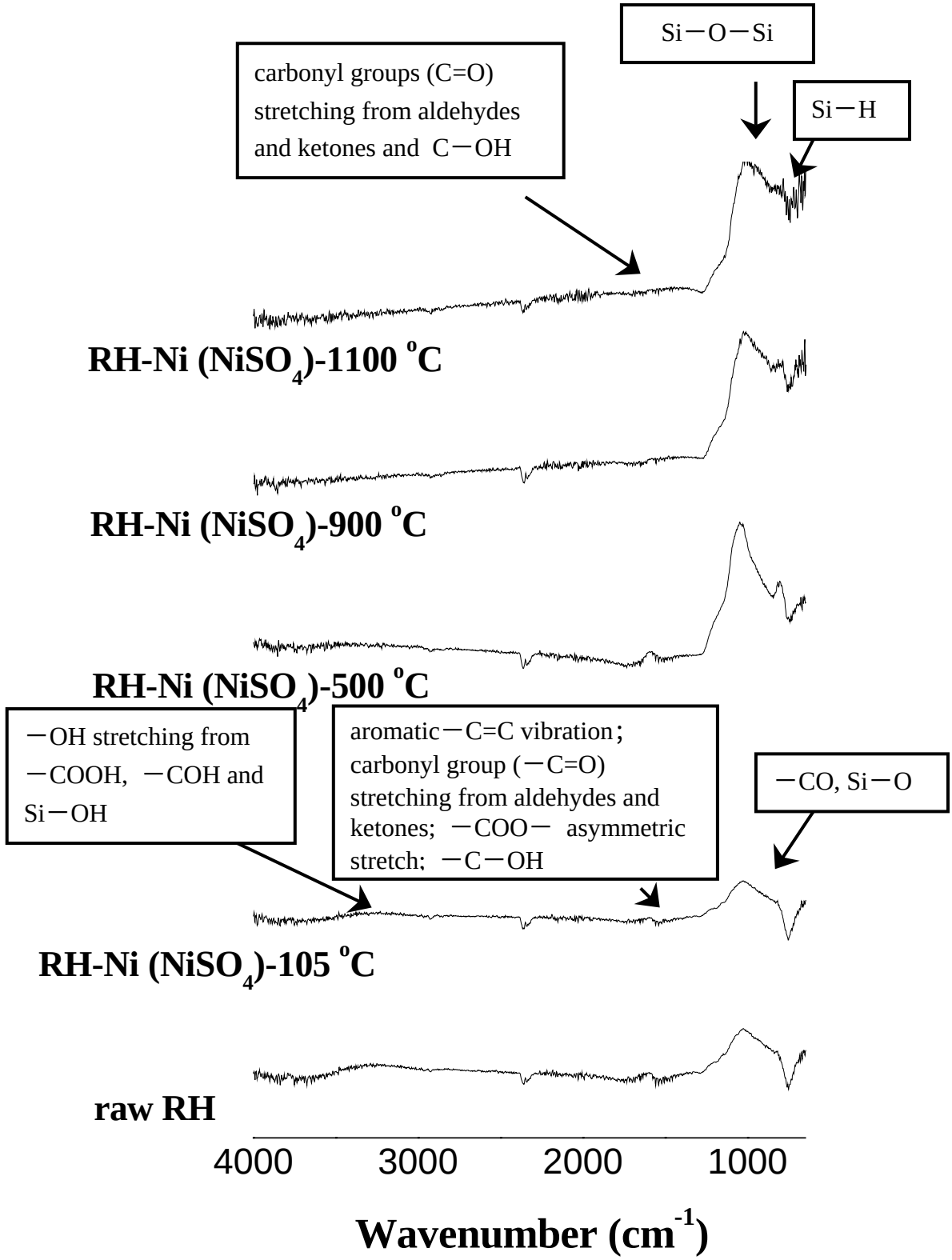
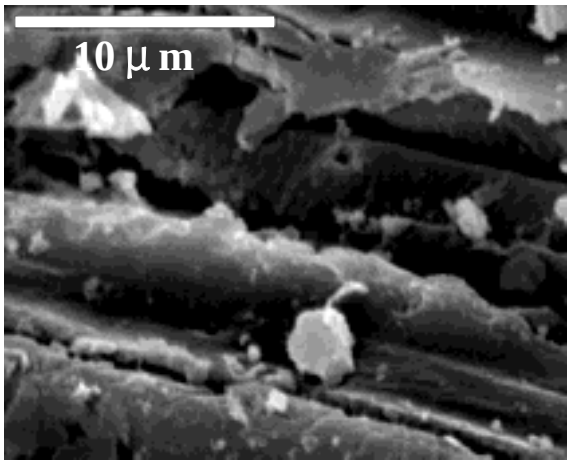
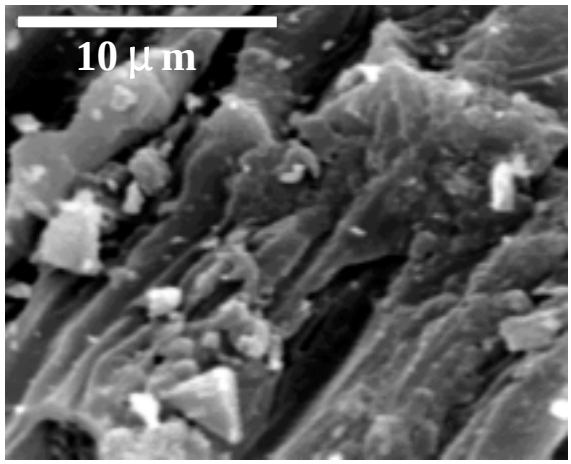


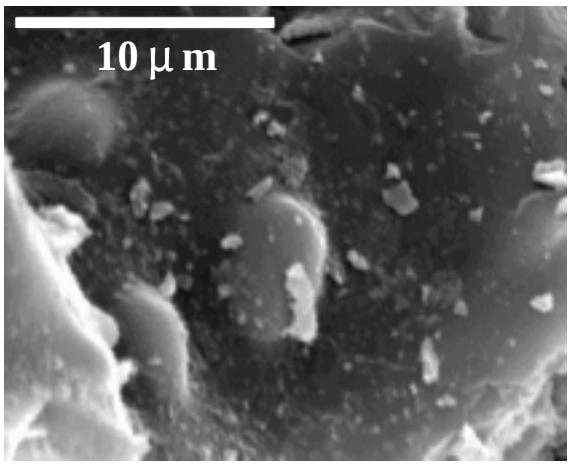

Fig. A-18. FT-IR spectra of raw RH and heated Ni ($NiSO_4$)-containing RH samples at different temperatures.



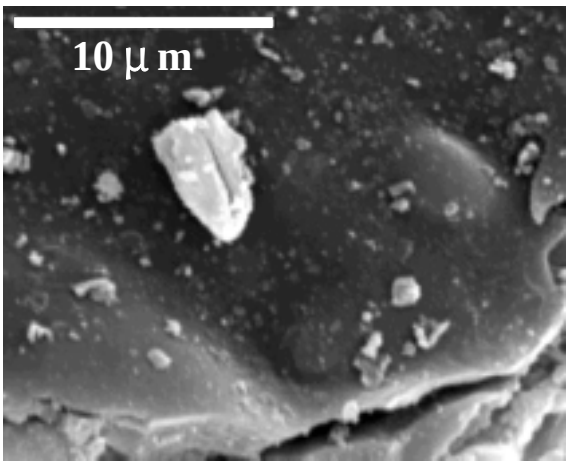

RH-Ni (plating)-105 $^{o}$C




RH- Ni (plating)-500 $^{o}$C




RH- Ni (plating)-900 $^{o}$C




RH- Ni (plating)-1100 $^{o}$C

Fig. A-19. Morphology (x5000) of Ni (plating)-containing RH samples after heating at different temperatures.

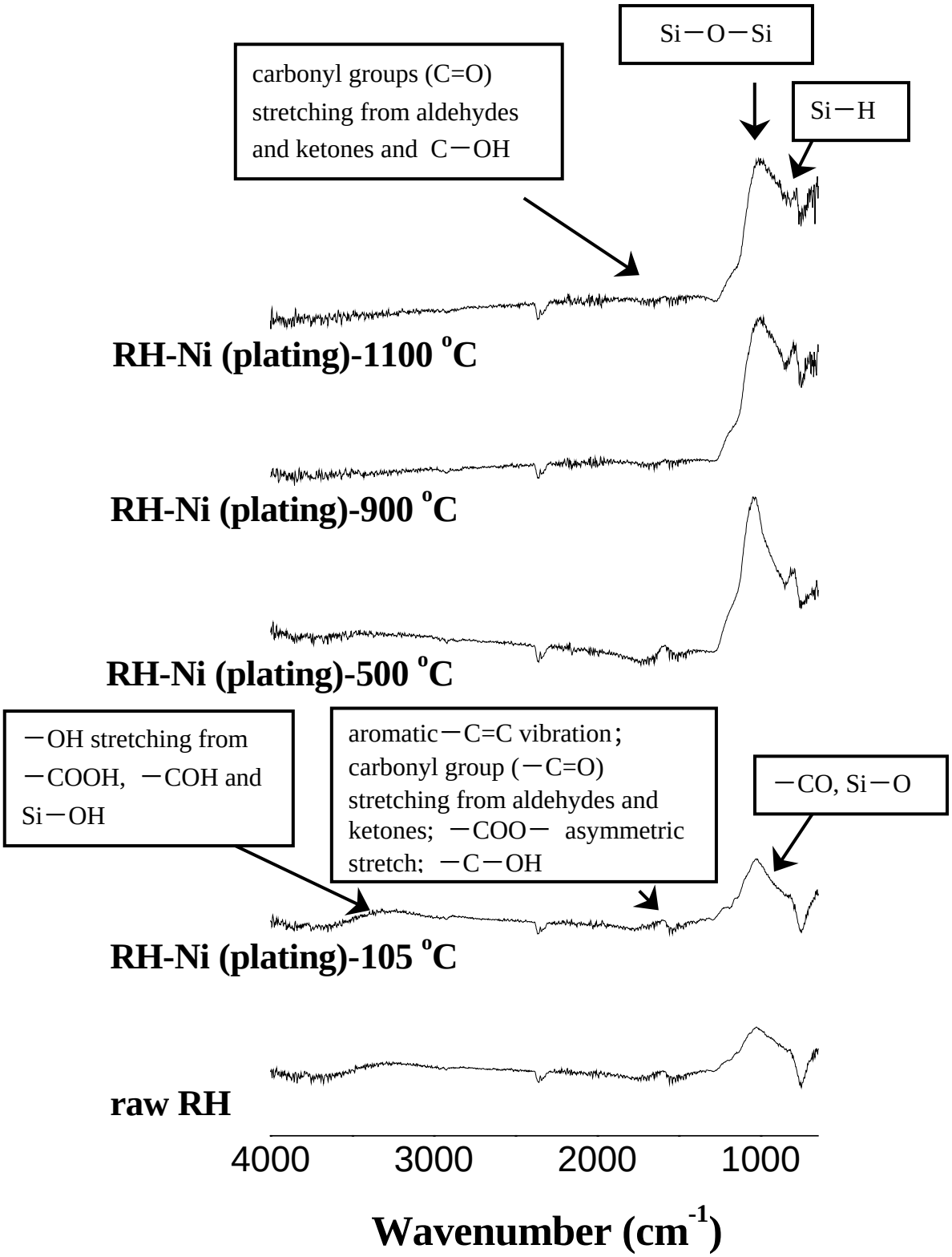



Fig. A-20. FT-IR spectra of raw RH and Ni (plating)-containing RH samples after heating at different temperatures.

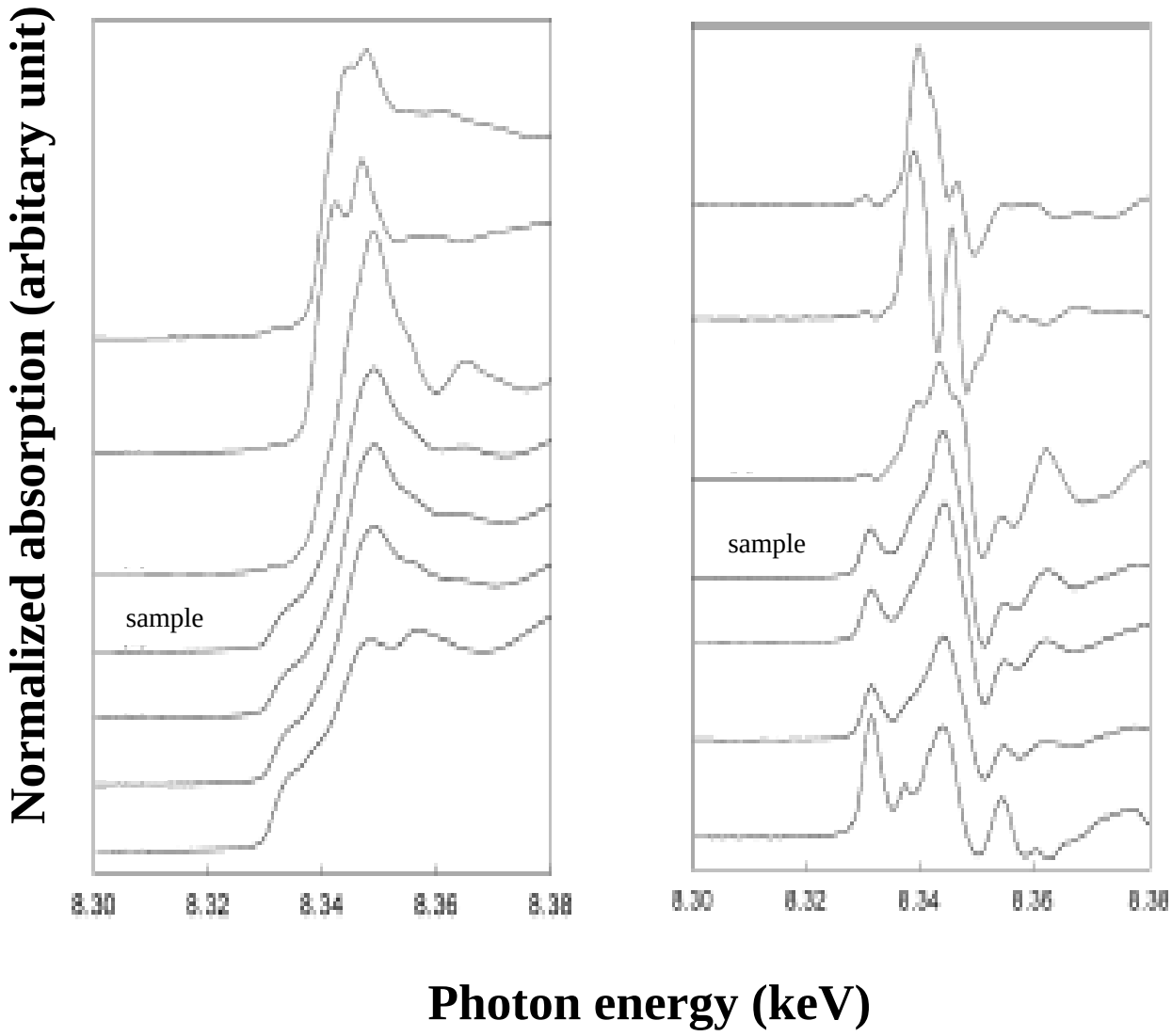



Fig. A-21.. XANES spectra and their first derivative spectra of raw Ni / $SiO_2$ sample 【Murthy, et al., 2004】.